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WHERE DID MARS GET ITS MOONS?

By E. MILLER, Lawrence, Kan. Read before the Academy December 31, 1896.

Newton's law of universal gravitation is exemplified in the movements of all the heavenly bodies, without exception. The illustration nearest to us is that of our solar system. Planets, asteroids, satellites, meteors, and meteoric swarms are controlled by it, and cannot escape from its power under any circumstances. It makes no difference whether the body moves in an elliptic, parabolic, or hyperbolic orbit, or in the direction of a right line; in any case the law holds good. The body moving may have such a marvelous velocity as to break away from the attraction of other bodies; yet the law remains in operation. In multiple systems of stars, some of whose orbits have been determined, and others whose orbits are now being investigated, the law is found to be valid. It is fair, therefore, to presume from analogy that the universe of matter is all subject to the law that celestial bodies everywhere act upon each other directly as their masses and inversely as the square of their distances.

It is true that the motion of a body in space may be so great as to effectually prevent the operation of the law, in spite of the attracting force of any other body, or of a number of others, or of an indefinitely great number of them, among which the moving body is passing. No. 1830 Groombridge is an example of a star traversing the celestial spaces at a velocity such that in the course of a great number of years the star will escape from the confines of our stellar system, and be forever after lost to our sight. Somewhere, some time, in the far distant future, 1830 Groombridge will be compelled to slacken speed, and acknowledge the supremacy of the law of universal gravitation, and will then no longer "devour its way" at the rate of 230 miles per second; in other words, it will become a captive star amenable to law, and obliged to travel in an orbit of some sort or other. Illustrations of the capture theory are to be found in our own solar system, especially in the case of comets that have entered the system from outer space, and also of those remains of disintegrated comets — meteoric swarms. There are families of comets belonging to our system that became members of it through the powerful influence of the giant planets. In every case of a comet of short period of revolution its orbit is found to be at certain points very close to the orbit of Jupiter, and when the comet's path crosses that of Jupiter, as Professor Young says, "one of the nodes is always near the place of apparent intersection, and if Jupiter were at that point on its orbit at the time when the comet was passing, the two bodies would really be very near each other. The fact as we shall see is a very significant one, pointing to a connection between these erratic bodies and the planet. This is true of all comets whose periods are less than eight years." Some one has recently suggested that the fifth moon of Jupiter is the result of the capture of a comet by the planet. Is it not possible that some of the moons of the giant planets may have been comets taken on the wing, so to speak, and subsequently transformed into satellites?

May not the movements of large comets passing through our system, hundreds of thousands of years ago, account for the backward revolution of the satellites of Uranus and Neptune? In the satellite system of Uranus, which apparently contradicts the theory of the nebular hypothesis, the plane of the orbits of the moons is inclined at an angle of 89°.2 to the plane of the ecliptic. We know that the inclinations of the orbits of the comets range all the way from 0° to 90°.

Now, putting these two facts together, we may see, first, that if the moons of Uranus and Neptune were formed in harmony with the nebular hypothesis, they acquired their anomalous backward movement of revolution around their primaries through the proximity of one or more large comets that at the time of the change were passing through our system; or, second, the comets moving along orbits that were at certain points close to the orbits of the planets were so completely captured as to have their cometary orbits destroyed, and they themselves transformed into moons, ever after to exist as moons or comet satellites of Uranus and Neptune. In this manner, comets transformed into moons or comet satellites would, by the superior attraction of the planets and their proximity, necessarily change the character of their orbits from that of the parabola to that of the ellipse.

Farther, instead of revolving around both the Sun and their captors, as many of them now do, with the Sun in the principal focus, the comet-satellites would move as do the moons of Jupiter and Saturn, merely attendants upon their primaries as the latter revolve about the Sun. It is pertinent to inquire how a comet, with a tail 50 or 100 millions of miles long, can be changed into a moon-like body. The nebular hypothesis tells how planets and satellites are formed out of rotating masses of nebulous matter; how a portion of that matter is thrown off, of which a controlling central mass has power sufficient to attract to itself all the other particles belonging to it; and how there results from this operation a compact body like that of a moon. A comet has a nucleus from which extends a tail longer or shorter, as the case may be. Near to and under the tremendous attraction of a giant planet, the motion of the comet in its orbit will be set up; an attraction will begin to be exerted upon that part of the tail nearest the nucleus, and a drift of cometary matter started at once toward the now more powerful center of attraction located in the nucleus; and this attracting force will increase as long as the cometary matter of the tail continues to flow toward the head. Portions of the tail may be lost in space, to be ever after invisible, or to become a meteoric swarm.

When our solar system was still in a nebulous condition, and rings of matter were beginning to be thrown off, in all probability nebulous patches or wisps became disengaged, some from the original nebulous field, and afterward some from the planetary masses; and these in time began to exert a powerful influence upon other portions destined to become satellites. The disturbing effects of the nebulous wisps exerted in every direction were sufficient to produce the backward movements of some of the moons.

This theory of necessity implies that the comets or nebulous patches may have been in that early formative state vastly more numerous than now, and of greater mass and density than the satellites themselves, or rather the masses of which the satellites were formed. Otherwise, such wonderful results could not have been produced. It may be supposed, too, that the nebulous patches or wisps referred to were assisted by immense cometary bodies that have not yet lost much of their matter by disintegration. The interplanetary spaces may have been full of nebulous wisps and comets, each working out its own destiny and influencing the destiny of its neighbors, at the time of the world-making of our system. An examination of the nebulæ in Canes Venatici, in Virgo, in Orion, and of the wisps around the Pleiades, will show almost beyond a doubt how such wisp-like and cometary forms do their work. The well-known law of a moving body—that it will continue to move in the direction given it by the original impulse just so long as it remains solely under the control of that impulse—is universally true; but when acted upon by some other force not in the same line, its direction will be changed, and the body will move along the resultant line. So it was with the nebulous patches that afterward became planets or satellites; but those that failed to materialize as planets or satellites, as well as the comets that were not transformed into cometary satellites or meteoric swarms, escaped from our system, and so doing left their impress upon some of the members of the solar system, as in the case of the moons of Uranus and Neptune. Their size and number would find better conditions for producing anomalous results on those far distant fields of space than their diminished size and number would find hundreds of millions of miles nearer the center of the nebulous mass about which all were revolving.

The disturbing force, however great, that was exerted by them was not powerful enough to draw the satellites away from the grip of their primaries. Suppose some great attracting force should appear in the midst of, or near to, the Jovian system: At once the moons of that planet would be more or less disturbed; their movements would be radically changed, or Jupiter might lose them altogether. A comet of immense size, such as Laplace suggested as a possibility, might even destroy the mechanism of the Jovian system entirely. The same may be said both of the Saturnian system and the Earth-Moon system.

There lies between the orbits of Mars and Jupiter a belt of tiny planets, the so-called asteroids, of which more than 400 have been discovered, and to the list of which new ones are added every year. Whether they came into existence, each as an independent body, or all were formed originally out of the nebula as a single planet, like the Earth or Mars, and then by a series of explosions, first of the planet itself, and then of the fragments as they were hurled in various directions into space; or still in the form of a planet, it was struck by some immense body on its way through the solar system from the depths of space — a comet or other unknown visitor — it matters not. Some of these little bodies have great eccentricity of orbit. Liberatrix, the 125th of the asteroids, discovered by Professor Henry in 1872, is, when nearest the Sun, 184 millions of miles distant from that luminary, and when farthest the distance is increased to 380 millions, making the longest axis of its orbit vastly greater than its shortest. Æthra, 132d, discovered by Watson in 1873, is a little over 149 millions of miles distant when nearest the Sun, and 333 millions of miles when farthest away. The longest axis of Æthra is at least 184 millions of miles longer than its shortest.

The inclination of the orbit of Æthra to the plane of the ecliptic is 25°, a little greater than the Earth's obliquity. Now, when Mars is nearest to the Earth, at the time of its most favorable opposition, the planet is distant from the Sun 128 millions of miles, and when farthest from the Sun, Mars is 154 millions of miles distant. But the inclination of the orbit of Mars to the plane of the ecliptic differs considerably from that of the asteroid Æthra. Let us compare the distance of Mars when farthest from the Sun with the distance of Æthra when nearest the Sun and ascertain if possible the probable results of such an investigation. The following table of measurements of the orbit of Mars, as given by Holden, and the corresponding one for the asteroid Æthra, compiled by Mr. D. P. Todd, of Amherst College, will assist in reaching a conclusion:

Nearest the Sun, Mars is 128 millions of miles distant; Æthra 149 millions. Farthest from the Sun, Mars is 154 millions of miles distant; Æthra 333 millions. Eccentricity of orbit of Mars is .093; of Æthra, .38. Inclination of orbit of Mars is 1° 51′; of Æthra, 25°.

The great eccentricity of the orbit of Æthra as compared with that of Mars, taken in connection with the nearest distance of Æthra to the Sun and that of Mars when farthest, will show that if the two orbits were in the same plane that of Æthra would intersect that of Mars at two points and at various times, once certainly when Mars would be passing aphelion and the asteroid perihelion. The accompanying figure will illustrate the supposition, the plane of the paper representing the plane of the orbits.

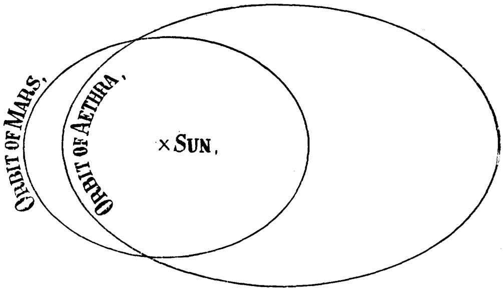

Fig. 1.

Anywhere to the right of the Sun's place, Mars would exert a tremendous pull on the asteroid, and especially so at the points of intersection. But as the orbit of the asteroid cuts the plane of the ecliptic at an angle of 25°, and that of Mars at an angle of 1° 51′, then the probability that the planet and the asteroid will pass through the plane of the ecliptic at the same or nearly the same time, and at points relatively the same, as if both in the same plane, will be somewhat diminished, but far from vanishing.

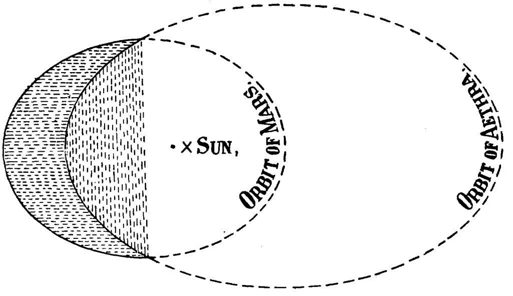

Fig. II.

In figure II the plane of the paper represents the plane of the ecliptic, the large ellipse the plane of the asteroid's orbit, the small ellipse the orbit of Mars. It is clear that notwithstanding the great difference between the angle formed by the intersection of the orbit of the asteroid and the plane of the ecliptic, and that by the intersection of the orbit of Mars and the plane of the ecliptic, there will come a time when the planet and the asteroid will get very near each other. Then the attraction of Mars at such close range, will be sufficient to change forever the direction of motion, and the plane of the orbit of the asteroid. What will then be the fate of Æthra? Under the conditions named, the asteroid will be transformed into a moon revolving about Mars as its primary, and so constituting one of the family of the planet.

However many asteroids there are, or whatever the width of the asteroidal belt is, it may be considered probable that there are hundreds or perhaps thousands of them so small as to be invisible even with the best telescopes, many of which move in orbits quite adjacent to the orbits of both Jupiter and Mars. Not only may some of them become satellites of the two planets, but there may be satellites of the two, invisible as yet, that were once asteroids pursuing their way around the Sun, influenced by the perturbing influences of either Jupiter or Mars. The asteriodal belt may, for all we know, extend all the way from the orbit of Mars to that of Jupiter, and the liability that some of them should be captured by their giant neighbors becomes almost, if not altogether, a certainty.

Then, if all the foregoing be true, it may be affirmed with a reasonable degree of probability that the two moons of Mars, Deimos and Phobos, at one time in the far distant past were members of the asteroidal group. Their size also seems to indicate their origin, one of which, the larger being not more than 16 miles in diameter, and possibly only seven miles. The time of revolution of Phobos, the inner moon, is 7 hours 39 minutes. That is to say, it revolves about Mars a little more than three times every 24 hours, and presents all the different phases of new moon, first quarter, full moon, and last quarter, at each revolution. Young says that "this rapidity of revolution raises important questions as to the theory of the development of the solar system, and requires modification of the views which have been held up to the time of their discovery. If the nebular hypothesis is true, a shortening of the satellite's period or a lengthening of the planet's day must have occurred since the satellites came into being." Now, a shortening of the satellite's period of revolution indicates that its orbit has been contracted to smaller dimensions; and this shortening may have been going on for a long time, so that at the time the shortening began the satellite was far enough away to be in the zone of asteroids; in fact, an asteroid itself.

The conclusion, therefore, which was referred to in the beginning of this discussion, is that, owing to the proximity of the asteroidal belt, the intersection of the orbits of Mars and Æthra, the small size of the asteroids and the moons of Mars, the red planet captured its moons from the asteroidal group. And, if this be so, then Jupiter some time in the past has done a like thing.

The future, supplied with more powerful telescopes and appliances, may reveal to our gaze more moons still revolving about the two planets, of which some were captured, and since that time have been playing the role of satellites.

NOTES ON INJURIOUS INSECTS.

By S. J. Hunter, Lawrence, Kan. Read before the Academy January 1, 1897.

The year just closing has witnessed the recurrence of some familiar insect pests, and the presence of forms strange to many because of previous scarcity in this locality.

The notes that follow are based upon correspondence received at the department of entomology and upon field observations made by members of the department.

Army-worm (*Leucania unipunctata*).

First appearance in state, 1876; again, 1891. This year present in damaging numbers in Douglas, Leavenworth, Ottawa, Brown, Harvey, Cloud and Ellsworth counties.

The worm is the larva of a fawn-colored moth of variable size, average having wing expanse of an inch and a half. Front wings freely sprinkled with black dots. Back of center of each wing is the characteristic white spot. The hind wings are translucent gray.

The eggs are deposited upon dead grass and old stubble between stalk and base of leaves. Some adults emerge late in the fall; the majority, however, appear early in the spring. When newly hatched the larva is dull white in color. When full grown its general color is dingy black with five light longitudinal stripes. The common name comes from great multitudes moving in one direction. The traveling habit is not instinctive, but forced by scarcity of food brought about by presence of large numbers.

Among the remedies for checking this pest are burning old grass, stubble, and old trash liable to form receptacles for eggs and hibernating larvæ. Doubtless the custom of burning all grass lands in this state in the years of early settlement accounts for the comparative absence of this worm. Ditching and fencing will prevent the progress of worms from one field to another until they may be destroyed by crushing. While this enemy of agriculture is legion, it is pleasing to note that its natural enemies are many. So effective are these predacious and parasitic insects[*] that the larvæ often disappear before they have become ready to pupate.

WHEATHEAD ARMY-WORM (*Leucania albilinea*, Guenée).

Numerous reports of the ravages of this insect came from various localities in the northern and western parts of the state during May and June. Hodge Bros. wrote from Abilene "The ground is covered and they are doing great damage." John E. Frost, land commissioner of the Santa Fe railway, estimated the damage over central and western Kansas to the wheat to be from 1 to 25 per cent. of the crop. The other reports were alike in tone.

The adult insect is a moth expanding about 1½ inches, front wings pale straw, hind wings satiny white. The larva, a brown and pale yellow caterpillar, feeding at night, eats the kernels out of the head of wheat, leaving a head of chaff. The casual observer will first see an abundance of chaff around the foot of the plants. It appears about (Riley) the time wheat is in the milk. Its first recorded appearance in this state was in 1876.

Prof. J. B. Smith, in *Insect Life*, Vol. VI, pp. 189, 190, says: "This is one of those creatures against which we are more or less helpless; and the only advice that I was able to give to the farmers was to harvest their wheat just as soon as they possibly could. The advice was followed very generally, and a conservative estimate placed on the damage done was 10 per cent. of the crop. A very large proportion of these larvæ were parasitized, principally by a tachinid fly, but the fact that so large a proportion was parasitized did not, so far as I have been able to ascertain, lessen the injuries sustained by the farmers in the least."

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[*] Insects attacking army-worms:

PREDACIOUS BEETLES....	Cicindela 6-guttata, Fabr.
	Harpalus caliginosus, Fabr.
	Calosoma calidum, Fabr.
	Calosoma externum, Say.
	Calosoma scrutator, Fabr.
	Calosoma wilcoxi, Lec.
	Pasimachus elongatus, Lec.
	Cicindela repanda, Dej.
	Elaphrus ruscarius, Say.
	Amara angustata, Say.
	Harpalus pennsylvanicus, Dej.
FLIES	Yellow-tailed tachinid fly, Exorista lucaniæ, Kirk.
	Exorista flavicauda, Riley.
HYMENOPTERA............	Microgaster militaris, Walsh.
	Penzomachus minimus, Walsh.
	Ophion purgatus, Say.
	Ichneumon leucania.

FOREST TENT-CATERPILLAR (*Clisiocampa sylvatica*, Harris).

From the southeastern portion of the state, notably Chautauqua and Elk counties, come reports of the defoliation of both forest and apple trees by a caterpillar formerly unknown in these localities. Specimens sent to the department were recognized as the forest tent-caterpillar.

The eggs from which the worm hatches are deposited by the moth, about the middle of June, in layers surrounding the twig at an equal depth, the ends of the cylindrical mass being squarely docked. This square ending enables us to distinguish this insect clearly from the apple-tree tent-caterpillar (*Clisiocampa americana* Harris), whose egg masses taper gradually down to the twig. I call especial attention to this fact here, since in the egg state our best opportunity for prevention occurs. The eggs in each mass number about 400. In color they are cream white. The mass is shaped similar to a truncated cone slightly rounded at the base. Eggs are protected from the weather by a brown varnish. The mass remains unchanged over winter, during which time they are easily detected upon the leafless trees.

The young hatch from this mass about the last of the following March; and, though the buds may not have opened, these little creatures are wonderfully hardy, can fast for two or three weeks if need be and withstand much inclement weather. The full-grown caterpillar is pale blue, tinged on sides with gray, and everywhere sprinkled over with black dots. It measures about an inch and a half in length. The common name arises from the little web or tent spun by the larva in the nearest fork. Here they live in company, moving out from time to time to feed upon surrounding leaves and increasing the size of their habitations as they grow.

The artificial remedies are destroying egg masses wherever found, spraying leaves with London purple or Paris green, destroying caterpillars collected in tents. The most effective remedy, however, is pruning off in the winter time the easily-detected egg masses upon the twigs of the leafless trees.

SPRING CANKER-WORM (*Anisopteryx vernata*, Peck).

In the spring the writer visited a number of orchards almost defoliated by the small grayish measuring worm. The worm is about an inch in length, travels with looping motion, and when disturbed lets itself down from the limb by a silken thread.

The wingless female issues in spring from chrysalids which have passed the winter in the ground, and soon deposits its eggs. These hatch about the time the leaves unfold from the bud, and are full-fed, ready to pupate, the latter part of May. The apple crop in north-central counties was seriously affected by this pest.

Among the many remedies, spraying, with either London purple or Paris green, during the heat of day when larvæ are most active, is the most effective after the worm has appeared on the trees.

Barriers formed by small rolls of rags placed around the trunk of the tree a foot or so from the ground, then freely coated with tar, prevents the ascent of the wingless female to deposit eggs and, later, the larvæ to feed. Spraying, however, at this time serves two purposes. In addition to destruction of canker-worm, the young codling-moth worm is also destroyed in the flower of the forthcoming apple. The quality of the apples gathered from orchards so sprayed under direction of the department was highly satisfactory to the owners, who commented freely upon absence of worms in mature fruit.

ELM-TWIG GIRDLER (*Oncideres cingulatus*, Say).

Shade trees, prominent among them the elm, were liberally pruned this fall by this industrious wood-cutter. Its presence is made known by the numbers of small branches strewn beneath the trees. In these branches are to be found the eggs deposited singly at the base of the twigs beneath the bark. This insect was reported at work in Atchison, Dickinson, and Douglas counties.

A number of the adults were kept in the laboratory during their working season this fall, and careful study made there, as well as upon affected trees on the campus. Mr. P. E. Parrott, a student of this department, has given this subject special attention, and will report fully later on.

CHINCH-BUGS (*Blissus leucopterus*, Say).

The life-history and the destructive habits of this insect are too well known to require further description. The department has continued the dissemination of the infectious diseases. Repeated demands from some localities each year and highly satisfactory reports from a great majority of farmers using the remedy are gratifying to the department. While no further funds are at hand for the prosecution of the work, the department has decided to continue the work and render still effective service to the agriculturists, the only requirement being that all demands for infection be accompanied by postage for delivery of diseased bugs.

The above is a brief summary of the work of the most destructive insects during the past year. These lilliputians are enemies well worthy the attention of every agriculturist. While many points are familiar, there is much to learn in order to more successfully cope with them. The department will highly appreciate reports and coöperation of the Academy and others interested in making the desired knowledge more complete.

NOTES AND DESCRIPTIONS OF *MYDAIDÆ*.

By S. W. WILLISTON, Lawrence, Kan. Read (by title) before the Academy January 2, 1897.

Collections of Diptera, even large ones, rarely include many specimens or species of *Mydaidæ*. The extent of individual variation is, in consequence, not well known. I have had the opportunity of studying most of the known genera and nearly 30 species. Much of the literature is inaccessible to the general student. I trust, therefore, that the following tables of the North American species will be useful, notwithstanding that they have been in large measure compiled from the often incomplete descriptions:

LEPTOMYDAS.

I would call attention to the fact that the sexes differ very markedly in coloration in this genus, and I suspect that the species described by Osten Sacken from females may not in each case be distinct from those described by Loew from males.

1.—Black, legs for the most part black 2
Luteous or reddish, legs yellow or rufous 3
2.—Proboscis short, the labella not incrassate; first posterior cell closed; femora black, the knees reddish; wings blackish..*tenuipes* Loew (male).
Base of hind femora and their tibiæ light yellow; wings cinereous hyaline; first posterior cell open ....*venosus* Loew (male).